124
84-23

85 291

FOREST PEST MANAGEMENT
Pacific Southwest Region

Report No. 84-23

3430 Evaluation
May 31, 1984

BIOLOGICAL EVALUATION OF A PROPOSED DEVELOPMENT SITE AT GRANT GROVE, KINGS CANYON NATIONAL PARK

Detlev R. Vogler, Plant Pathologist
John R. Pierce, Entomologist

ABSTRACT

We evaluated insect and disease pest and hazard tree conditions in a mixed conifer stand at Meadow Camp near Grant Grove, the site of a proposed lodge development. Although there was little current mortality, we found a number of potential hazard trees and several disease pests affecting white fir, including annosus root disease, dwarf mistletoe, and true mistletoe. We discuss the benefits of vegetation management to visitor safety and stand health, and present several management alternatives. We also report our observations of a white fir that fell near a Park Service employee's residence in December 1982, and suggest how similar failures may be prevented.

In July 1983, Acting Park Superintendent James Laney wrote to Forest Pest Management (FPM) requesting a biological evaluation of a proposed development site in Grant Grove. The following September we met with Tom Warner, Park Resource Technician, and evaluated the insect and disease pest conditions in Meadow Camp, the likely site for a new lodge. We also visited the Grant Grove government employees' housing area, where we examined a white fir that fell near a residence in December 1982.

PROPOSED DEVELOPMENT SITE AT MEADOW CAMP

We spent most of two days examining stumps and live trees throughout the existing Meadow Camp concession and adjacent Park Service maintenance site. The mixed conifer stand is dominated by white fir and sugar pine, with lesser amounts of incense-cedar and Jeffrey pine; Jeffrey pine predominates on the rocky hillsides. Site quality is generally good-to-

USDA, FOREST SERVICE, PACIFIC SOUTHWEST REGION
State and Private Forestry, Forest Pest Management
630 Sansome Street, San Francisco, California 94111

excellent. Stocking ranges from none in scattered treeless openings, to moderately high in groups of pole-size and larger white fir, incense-cedar, and sugar pine (basal area about 350 square feet per acre). Large stumps are numerous, and indicate that old-growth trees were once more common, but have been dying gradually for many years. The general impression is that of a mixed-species, old-growth stand that has stagnated and begun to break apart. Compared to the desolate old-growth fir stand near the Grant Grove store, however, the Meadow Camp site contains a wider range of age classes and is still adequately stocked for recreation and aesthetics.

The results of our survey are shown in Figure 1 (page 10) and explained in the accompanying key (pages 11-13). Throughout the area mortality was slight and we saw little insect activity. The major pest problems were caused by three diseases affecting white fir: annosus root disease (caused by Fomes annosus), dwarf mistletoe (Arceuthobium abietinum f. sp. concoloris), and true mistletoe (Phoradendron bolleanum subsp. pauciflorum). Annosus infection has created several openings or disease centers that are gradually enlarging as white firs on the periphery become infected, decline, and die. The dwarf and true mistletoes have thinned the crowns and reduced the vitality of many of the large, older firs. Twelve known or suspected annosus root disease centers were found and marked on the map; in all but one case the hosts were white fir. We also mapped the locations of many of the conifers that were 30" dbh or larger, since we felt that these trees would be the first to decline or become hazardous following site modification.

A number of trees in the stand had been hazard-rated by the Park and marked for further observation (see map notes, nos. 10, 15, 23, 26, 29, 34, and 36). We also examined several other large trees that had indicators of potential hazard, although they had not been marked (map nos. 6, 7, 18-20, 28, 33, and 37). We bored several of these trees to determine whether the radial thickness of the outer sound wood was adequate to maintain the trees' strength. Generally, a conifer can suffer up to one-third loss in strength -- equivalent to a 70 percent loss of total wood diameter inside the bark -- without becoming hazardous (see Table 1). One of the trees did not meet this minimum standard and was judged to be hazardous (map no. 7). However, the presence of open basal wounds and fire scars on several of the trees examined increased their risk of failure, despite their having adequate thickness of sound wood at breast height (map nos. 6, 10, 15, 23, and 26).

DISCUSSION

Since trees and other vegetation in National Parks are managed solely for their aesthetic and recreational values, insects and diseases are pests only if they cause them to become hazardous, or if they kill them outright, resulting in loss of beauty, shade, and screening. When recreational facilities are built in mature or old-growth forests, natural regeneration usually ceases, and within a few decades, as the older trees succumb to insects, disease, and other stresses, the site is denuded and its aesthetic value declines. A good example of where this

Table 1. Minimum safe standard for defective trees applied as average[1] thickness of outer sound wood of the trunk with center rot or hollow representing 70 percent of the total wood diameter, equivalent to one-third loss in strength. (From Wagener, 1963.)

Diameter of tree inside bark (in.)	Thickness of sound wood (in.)[2]	Diameter of tree inside bark (in.)	Thickness of sound wood (in.)[2]
16	2.5	44	6.5
20	3.0	48	7.0
24	3.5	52	8.0
28	4.0	56	8.5
32	4.5	60	9.0
36	5.5	64	9.5
40	6.0	68	10.0

[1]Assumes no modification (opening, wound, catface, etc.) is applicable.

[2]Figures rounded to nearest one-half inch.

process leads is the cabin area near the Grant Grove store, where there is no longer an understory and the few remaining old-growth firs and pines are mostly declining, dying, or hazardous. In these situations, the Park Service attempts a holding action, removing trees as they die or become hazards, until the site is finally abandoned. However, choices are much greater when planning new facilities in stands that have a varied age and species structure, and are reasonably free from disease and insect pests. Prior to construction, it is possible to manage the vegetation so that a multi-species, many-aged stand thrives and maintains itself, but this requires an intensive program of tree removal, pruning, planting, and periodic maintenance. One key to successful vegetation management is to identify the type of stand that is both possible and desirable, and then so design and manage it that the stand structure and facilities complement rather than conflict with each other.

MANAGEMENT ALTERNATIVES

The following alternatives cover a range of options: minimal vegetation management (removal only of those trees that are in the way of buildings, roads, and trails); protection of the residual stand during construction; selective removal of trees that have a high risk of death or hazard potential; direct suppression of annosus root disease, dwarf mistletoe, and true mistletoe; prevention of insect-caused mortality;

and intensive vegetation management, including removal of many old-growth trees and extensive planting of conifers, hardwoods, and shrubs.

Minimal Vegetation Management

This is essentially a no-action alternative, since vegetation management is limited to removal of only those trees that are in the way of buildings, roads, and paths. The guiding principle of this alternative is to preserve the present appearance of the stand as much as possible. In some cases trees will be retained close to buildings or roads in order to save the crown cover and forested appearance without the added expense of planting. Existing openings and annosus centers will be used to place structures so that the impact on the stand will be reduced as much as possible.

Since this alternative causes the least obvious disturbance, the site may be little changed initially. In the long run, however, the decline of dwarf mistletoe- and true mistletoe-infected and root-diseased trees, along with increased hazard from heart rot, mechanical damage, soil compaction, and dead tops and limbs, will cause the site to degrade within a few decades. The attempt to preserve as many trees as possible will expose leave trees to butt and root wounds, reduce tree vigor, and invite decay. The likely failure of natural regeneration and the lack of plantings will decrease the age diversity of the stand as the old-growth dies and the present understory becomes dominant. Spreading from the overstory above, dwarf mistletoe will infect the smaller firs, perpetuating the disease; firs in overstocked groups or near annosus infection centers may grow slowly and become severely infected with mistletoe.

Protection of the Residual Stand during Tree Removal and Construction

Overstory removal and construction activities in true fir stands can severely injure the leave trees, leading to unsightly wounds, substantial decay, and sometimes tree death. Although developed for commercial logging operations in young-growth true fir stands (Aho et al. 1983), these guidelines are also applicable to site development in Parks, and should greatly reduce damage to the residual stand.

- Restrict the construction and logging season. Do not allow entry during the spring and early summer when the bark is loose.

- Restrict the size and type of equipment. Match the logging equipment to the type and size of material being removed.

- Mark the leave trees. When leave trees rather than cut trees are marked, the operator becomes more aware of which trees are to be protected.

- Lay out skid roads in advance of logging. Skid trails should not be cleared wider than the skidding vehicle. Use straight-

line skid trails, and follow the routes of proposed roads and paths.

- Leave buffer or bump trees. When possible, leave logs and bump trees along the margins of skid trails. Remove bump trees during the last stand entry.

- Limb, top, and buck trees before skidding. Avoid whole tree logging, and cut limbs flush with the tree bole.

- Limit the log length. Skidding long logs increases the likelihood of damage to leave trees. Adjust log lengths to the spacing of the residual stand.

- Log the skid trails first. To keep the skidder from veering into leave trees, cut the stumps in the skid trails as low as possible, no more than three-to-four inches high.

- Use directional felling. Fall trees toward or away from the skid trails to reduce skidder maneuvering. Back the skidder toward the direction of the fall.

- Do not thin stands too heavily. Sudden exposure to sunlight can cause considerable sunscald to thin-barked species.

- Prevent new annosus root disease centers. Treat all conifer stumps with granular borax according to label instructions.

- Gain the contractor's cooperation. Through training and close supervision, convince operators that damage to leave trees is unnecessary and will not be tolerated.

Selective Removal of Trees with a High Risk of Death or Hazard Potential

Prior to construction, risk- and hazard-rate the stand, and remove those trees, principally mature white firs, with the greatest potential for failure or death. Apply the hazard guidelines developed by Wagener (1963) and others, and modify use of the Park's Hazard Tree Rating System (see Appendix) so that you remove trees with hazard rating scores lower than would normally be allowed. In this way, trees that may become hazardous in the next decade will be removed prior to construction.

The purpose of risk-rating is to identify trees that will die shortly, usually within 10-15 years. Pines and firs with dwarf mistletoe ratings of 5 and 6, and declining firs next to annosus root disease centers or with severe true mistletoe infestations are obvious candidates for removal. Several more subtle risk indicators, including branch angle, crown density, and crown raggedness, are discussed in Risk- and Hazard-Rating Systems for Mature Red Fir and White Fir in Northern California (Ferrell 1980). This report and another entitled Growth Classification Systems for Red Fir and White Fir in Northern California (Ferrell 1983), although intended for use in northern and central California, include

several excellent color photographs that may prove useful in developing fir risk-rating standards for Grant Grove.

Suppression of Annosus Root Disease, Dwarf Mistletoe, and True Mistletoe

These alternatives are intended to suppress disease pests directly so that they have minimal impact on the stand for the life of the development. Immediate effects will be much greater than in the previous alternative, since many more trees will be pruned or removed, but the long-term benefits of improved stand and tree vigor will outweigh the short-term gains from preserving as many trees as possible now.

Suppress Annosus Root Disease. Treating conifer stumps with borax will prevent the initiation of new disease centers, but it will not stop the spread of infection outward from existing centers. Restricting center enlargement by removing all susceptible hosts from a buffer strip around disease centers, or eradicating infection within centers by pulling all infected trees, stumps, and root material, are theoretically feasible, but unproven. These treatments would also be expensive and might not succeed, since it would be difficult to remove all inoculum, and undetected infections might occur beyond the periphery of the center. The most feasible alternative appears to be species conversion, either with non-host hardwoods or with tolerant conifers. If sufficient pines are present, they need not be removed from fir centers, since the disease is not observed to spread from fir to pole-size and larger pines; any firs remaining on the margins of or within centers with infected fir or pine would be susceptible. In disease center openings, pines may be planted where only fir stumps are infected, although there is some risk of infection; pines should not be planted in pine centers, nor firs in either pine or fir centers.

Suppress White Fir Dwarf Mistletoe. The sugar pines and Jeffrey pines are not infected with dwarf mistletoe, and are not at risk from the species infecting the white fir. In infected, two-story white fir stands, the understory is repeatedly showered with mistletoe seeds and its growth will be seriously affected by repeated upper crown infections. Research has shown that pole-size and smaller fir stands respond well to release and outgrow the upward spread of the parasite. Use the following guidelines in treating these stands.

- Remove the overstory to release the young-growth and prevent continued re-infection from above. Where this is not possible, the only alternative may be to select for or plant pines, incense-cedar, or hardwoods.

- Thin young-growth stands for optimum growth. The presence of mistletoe need not be the primary factor in selecting leave trees, but rather should be considered after crown class, percent live crown, and height growth. The larger firs with 50% or more live crown and slight infection (no dwarf mistletoe in the upper half of the crown, or an infection rating of 3 or less) will respond best to release.

- Create an even-aged stand to minimize spread between infected trees.
- Encourage non-host species as a barrier to spread.
- Do not prune branch infections. This treatment is biologically unnecessary in released true fir stands, and elsewhere it is expensive because of the frequent re-treatments necessary to remove latent infections from firs.
- Create and maintain infection barriers between treated and untreated stands. These may be roads, meadows, openings, or aggregations of non-host species. Generally, the host-free barriers should be as wide as the height of the highest dwarf mistletoe plants in the adjacent trees.

Suppress True Mistletoe in White Fir. True mistletoe is difficult to control because it is spread by birds that perch atop the tallest trees in a stand. Top pruning does not prevent reinfection, is unsightly, and exposes the cut stem to decay. The best alternative is to selectively remove severely infected trees that may die soon or that pose hazards to visitors. Infected firs that appear healthy may be saved.

Prevent Insect-Caused Mortality

Little insect activity was observed at the time of this evaluation, but the presence of several disease agents suggests that insect-caused mortality could occur in the future. The principal insect pests include bark beetles (Dendroctonus jeffreyi in Jeffrey pine and D. ponderosae in sugar pine), the fir engraver (Scolytus ventralis), and pine engraver beetles (Ips spp.). Attacks by bark beetles and the fir engraver are usually associated with overstocking, drought, dwarf mistletoe infection, or root disease, and may be prevented by silvicultural treatments that create and maintain healthy, vigorous stands.

In some cases, high-value specimen trees may be treated with insecticides to prevent bark beetle attack. Currently, Sevimol 4 (carbaryl) is registered for protection against the western pine beetle and the mountain pine beetle. To protect a tree, spray the larger limbs and the main trunk from the ground up to where the tree is about 4 inches in diameter. This should be done once annually in the spring so that there is a deposit of insecticide on the bark at the time beetles begin to fly. Trees which have already begun to fade or show other signs of successful attack should not be sprayed with any expectation of keeping them alive, since carbaryl is useful mostly as a protectant. The insecticide will not penetrate the bark sufficiently to kill many established beetles, but it will kill them as they emerge or attempt to invade. Use protective sprays only after careful consideration. Treatment may be warranted when high-value trees are temporarily stressed by drought or disturbance from construction, but treating individual trees is expensive and does not deal with the underlying factors that most often predispose stands to bark beetle attack.

Outbreaks of pine engravers are often associated with temporary stress, such as severe competition or sudden opening of the stand. Tree killing frequently occurs where green pine slash, which serves as breeding habitat, is left untreated during spring and summer. Fresh pine slash caused by thinning, dwarf mistletoe control work, construction, or winter storms can be treated in a number of ways to make it unsuitable for pine engraver breeding.

- Schedule slash-generating activities between mid-July and late December, when the slash has a high probability of drying out before the beetles can complete their development.

- In spring and early summer, treat slash shortly after cutting by lopping and scattering in sunny areas to speed drying, crushing or mashing with logging equipment to render it unsuitable for breeding, or piling and burning within a month of cutting. Another method is to pile slash in a sunny area and cover it with clear plastic; if the temperature under the bark in all parts of the pile reaches 120°F, all brood currently in the slash will be killed. In high-use recreation areas, the most acceptable treatment method may be chipping or removal from the site.

Intensive Vegetation Management

Combining the above alternatives with planting and careful site development offers the best hope for creating a healthy and vigorous recreation forest. Plans for diseased-tree treatment and thinning should be made before roads and buildings are sited; otherwise, architectural considerations may override essential pest prevention and suppression actions and, once the pest-ridden stands begin their inevitable decline, the value of the improvements may decline. Intensive vegetation management is expensive, but the alternative, as witnessed by the devastated stand near the Grant Grove store, may be more expensive in the long-run, both in dollars and in environmental costs.

Some excellent suggestions for building in forests are included in the publication **Protecting Trees when Building on Forested Land** (Koehler et al. 1983). The following excerpts from the chapter on construction and maintenance practices are particularly applicable to Park developments:

- Building decks or roofs around leave trees is a poor practice. Such trees are usually too close to the structure and their roots may be seriously injured by foundation construction, or their access to soil moisture compromised. Removing such trees can be extremely costly. Those that survive continue to enlarge in girth, requiring periodic alteration of the opening in the deck or roof through which they protrude. A good question to ask is, if no tree were growing in this spot, would I plant one here?

- Fence off single trees or groups of trees before construction to minimize root damage by soil compaction or stem damage by

equipment. As a rule of thumb, erect protective fences at the dripline, but be aware that feeder roots usually extend beyond this point.

- Change road and lot grades as little as possible. Not only will grading damage roots and set up conditions favoring soil erosion, it may also alter the contour of the land sufficiently to drastically affect the flow of surface and sub-surface water that resident trees depend on for health and survival.

- Dig trenches for underground utilities away from tree roots, even if the trench must curve to avoid roots. Consider tunneling below major roots of selected trees, where lines close to trees cannot be avoided.

- Do not backfill with earth or rocks around the trunks of trees. Broadleaved trees are especially susceptible to decline and death from improper backfilling.

- Avoid attaching above-ground utility wires to trees, or using trees as fence or sign posts.

- Avoid paving with either concrete or asphalt over root systems, or close to the trunks of trees. Asphalt laid over extensive areas, such as parking lots or pathways, should be at least partially permeable to water.

These and other suggestions covered in the text will reduce the chances that insect and disease pests will attack and overcome trees weakened by improper construction practices.

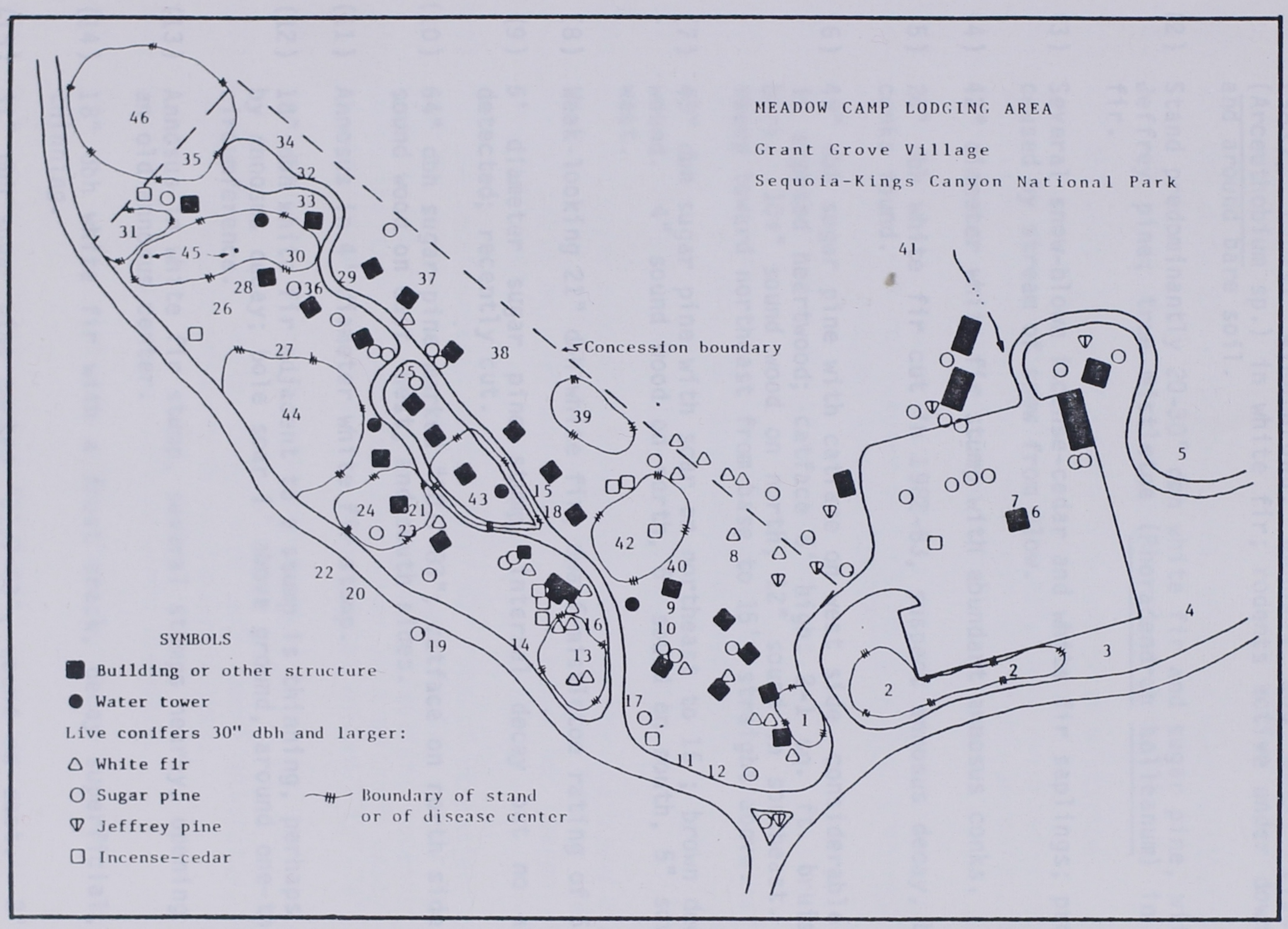

Figure 1. Locations of Disease-Infected Conifers, Major Structures, and other Features at Meadow Camp Lodging Area, Grant Grove Village, Sequoia and Kings Canyon National Parks, September 1983.

KEY TO PEST CONDITIONS AT MEADOW CAMP, GRANT GROVE

(1) Annosus root disease center (caused by Fomes annosus) near cabins 501-502: 2 white fir stobs, 2 white fir stumps (1 cut in 1982 or 1983), 1 fir windthrown; annosus and dwarf mistletoe (Arceuthobium sp.) in white fir; rodents active under down logs and around bare soil.

(2) Stand predominantly 20-30" dbh white fir and sugar pine, with one Jeffrey pine; true mistletoe (Phoradendron bolleanum) in white fir.

(3) Several snow-blown incense-cedar and white fir saplings; probably caused by stream of snow from plow.

(4) 42" diameter white fir stump with abundant annosus conks.

(5) 24" dbh white fir cut in 1982-83, suspect annosus decay, but no conks found.

(6) 49" dbh sugar pine with catface on west side, considerable decay in exposed heartwood; catface 5' high; 2-1 sq. ft. bruises on bark. 10+" sound wood on north, 12" sound on southeast. Bole sweep toward northeast from base to 15', straight above.

(7) 48" dbh sugar pine with scar on northeast to 15'; brown decay in wound. 4" sound wood on north, 6" sound on south, 5" sound on west.

(8) Weak-looking 21" dbh white fir, dwarf mistletoe rating of 5.

(9) 5' diameter sugar pine stump, internal decay but no annosus detected; recently cut.

(10) 64" dbh sugar pine marked "30/7-83"; catface on north side; 10+" sound wood on east, west, and south sides.

(11) Annosus in 4' diameter white fir stump.

(12) 18" dbh white fir adjacent to a stump is thinning, perhaps caused by annosus decay; bole scar 1' above ground, around one-third of circumference.

(13) Annosus in white fir stump, several stumps nearby, opening may be an old annosus center.

(14) 18" dbh white fir with a frost crack, decay superficial, crown thinning.

(15) 31" dbh sugar pine marked "31/7-83", wound on east. 8" sound wood on west, 7" sound on south, 4-1/2" sound on north.

(16) Recently-cut white fir stump, solid surface, no holes.

(17) Recently-cut white fir stump, solid surface, no holes.

(18) 42" dbh white fir with base grown into the concrete porch of cabin no. 510; crown looks healthy.

(19) 27" dbh white fir with bole swelling on side toward cabins; appears firm.

(20) 27" dbh white fir with three tops, true and dwarf mistletoe.

(21) 35" dbh white fir with true and dwarf mistletoe.

(22) 27" dbh white fir with severe true and dwarf mistletoe.

(23) 22" dbh white fir marked "32/7-83", has dwarf mistletoe but otherwise looks healthy; open scar (4" wide) on north, but at least 12" sound wood on south side.

(24) Four white fir stumps around cabin no. 515; entire area is open. Armillaria root rot (caused by Armillaria mellea) present, but no annosus found; suspect annosus center.

(25) 3' diameter white fir stump with annosus.

(26) 60" dbh incense-cedar with 9"-wide by 12'-high scar on east; tree marked "25/7-79". 12" sound wood on west side.

(27) Three incense-cedar stumps, brown decay, old.

(28) 63" dbh sugar pine with woodpecker work on the south and bleeding scar at base, but seems sound; top has a tight fork. Tree leans toward cabin no. 524 and should be watched for changes in the amount of lean.

(29) 75" dbh incense-cedar marked "37/7-83", 30%-of-circumference fire scar on northeast, a sweep in the upper bole, very large limbs high in the crown, and true mistletoe infection; rodents active under the tree, suggesting some lower bole or root decay; signs of bark-inhabiting insects. Tree is also marked "32/7-79".

(30) Annosus in 4' diameter white fir stump.

(31) Eight 25+" dbh white firs; true and dwarf mistletoe, crowns spotty; group is adjacent to an annosus center.

(32) Double white fir stump, annosus conks abundant.

(33) 55" dbh sugar pine with tight fork top directly over cabin no. 526.

(34) 55" dbh incense-cedar marked "38/7-83", open scar on one-third of circumference on northwest side.

(35) Annosus in two sugar pines.

(36) 22" dbh dead white fir marked "35/7-83"; tree has ambrosia beetles and had dwarf mistletoe.

(37) 58" dbh sugar pine with multiple tops; should be watched.

(38) Several 30-50" dbh white firs with large, dwarf mistletoe-swollen branches; group is predominantly mature and old-growth firs.

(39) Healthy-looking group of approximately 30" dbh white firs, good crowns, liable to dwarf mistletoe spread from group described in note no. 38.

(40) 20" diameter white fir stump with annosus conks.

(41) Mainly Jeffrey pine on this dry, somewhat barren, and rocky hillside stand.

(42) Opening that is a likely annosus center; absence or burial of stumps made diagnosis difficult.

(43) An opening in the stand that is a possible annosus center; no stumps.

(44) A stand of white fir, incense-cedar, and sugar pines with full crowns, good condition, and little dwarf mistletoe in the fir. Stocking heavy (basal area 350 sq. ft./acre).

(45) Arrows point to two white fir stumps; entire area is open and a probable annosus center.

(46) Large opening with many white fir stumps, annosus conks abundant; incense-cedar is seeding into the opening successfully.

WHITE FIR FAILURE AT A PARK SERVICE RESIDENCE

During a windstorm on December 22, 1982, a 46-inch dbh white fir failed some 90 feet north of Park Residence No. R-1612 at Grant Grove. There were no injuries and the house was undamaged, but the occupants felt they were lucky, since the 174-ft. tall fir could have caused considerable damage. According to Tree Failure Report No. 66-82, which was prepared at the time of the incident, the soil was saturated, the tree failed at the roots, and a dead top contributed to the failure.

Nine days before it failed, the tree was inspected and given a hazard priority rating of 4 on a 7-point scale (see the Appendix: Hazard Tree Rating System). The inspector observed that the tree had a slight lean away from the house, mistletoe (unspecified whether dwarf or true) in the crown and throughout the top one-third of the tree, and sparse, ragged foliage. He also noted, however, that there was no apparent external rot or decay, that increment cores revealed a solid wood structure without rot, and that the tree had already withstood high winds six days earlier without any visible damage. Based on this assessment, it was concluded that the tree should be left standing and inspected again in the spring (National Park Service Memorandum Y1815, dated December 16, 1982).

FIELD OBSERVATIONS

Tom Warner asked us to look at the tree, which in September was still intact on the ground, because he was concerned that the Park's normal inspection procedures had failed to detect an imminent failure. We found the root system to be extensively decayed, with about 75% of the roots rotted by either Fomes annosus or Armillaria mellea. Most of the roots had broken where they were decayed, usually about 3-4 feet from the root collar. Three major roots ranging in diameter from 6 to 10 inches had fruiting bodies (conks) of F. annosus attached to them. Judging by these observations, this fir had been suffering sufficient root decay to render it hazardous. However, neither the rot nor the conks would have been visible while the tree was still standing, and even partially excavating the roots and coring them with an increment borer might not have revealed the extent of decay.

One clue might have led to the correct diagnosis. Several annosus root disease centers were found within the residence site, and a large white fir stump about 40-50 feet from the failed fir had numerous annosus conks inside it. The fir was close enough to the stump for its roots to have become infected. In other words, the white fir was growing in an annosus center, and, because of its age and declining condition, could have been presumed to be infected with F. annosus.

DISCUSSION

Annosus root disease might have been detected if the inspector had excavated conifer stumps near the suspect white fir to search for conks of Fomes annosus, but he would not have been able to ascertain the

extent of decay. Nevertheless, inspectors should assume that a white fir may be infected with annosus if it is growing close to infected stumps. In particular, trees with sparse or ragged crowns, chlorotic foliage, and flat tops that are growing within or near infection centers are likely to have root decay. The hazard is greatest with true firs and incense-cedar -- infected pines are generally killed by bark beetles before their roots become extensively decayed, but infected true firs and incense-cedar often undergo severe loss of support roots while still alive.

A sharp pulaski and a shovel are useful for excavating stumps, since the conks may be deep within the stump and difficult to find. Generally, conks on pines are found beneath the bark just at or below the ground level, while conks in firs are found within decayed pockets in the middle of the stumps.

Some mention of a tree's proximity to suspected annosus infection centers should be included in the Hazard Tree Rating System. When large, old firs grow within or adjacent to infection centers, the likelihood of decay, the potential for failure, and the risk of damage are too great to ignore.

LITERATURE CITED

Aho, Paul E., Fiddler, Gary, and Srago, Mike. 1983. Logging damage in thinned, young-growth true fir stands in California and recommendations for prevention. USDA, Forest Service, Pacific Northwest Forest and Range Experiment Station, Research Paper PNW-304. 8 pp.

Ferrell, George T. 1980. Risk-rating systems for mature red fir and white fir in northern California. USDA, Forest Service, Pacific Southwest Forest and Range Experiment Station, General Technical Report PSW-39. 29 pp.

Ferrell, George T. 1983. Growth classification systems for red fir and white fir in northern California. USDA, Forest Service, Pacific Southwest Forest and Range Experiment Station, General Technical Report PSW-72. 18 pp.

Koehler, C. S., Hunt, R. H., Lobel, D. F., and Geiger, J. 1983. Protecting trees when building on forested land. University of California, Division of Agricultural Sciences, Cooperative Extension, Leaflet 21348. 11 pp.

Wagener, Willis W. 1963. Judging hazard from native trees in California -- a guide for professional foresters. USDA, Forest Service, Pacific Southwest Forest and Range Experiment Station, Research Paper PSW-P1. 29 pp.

APPENDIX: HAZARD TREE RATING SYSTEM USED IN SEQUOIA-KINGS CANYON[1]

The hazardous tree rating system used in these Parks comprises two basic elements. One relates to the tree itself, i.e., the relative degree or chance of imminent failure. There are three degrees, numbered 1 - 3, with 3 representing the highest chance for imminent failure. Assessment of a value depends upon many factors, such as the effects of the various pathogens on the structural soundness of trees, including roots, base, bole, and limbs. Other considerations may be mechanical structural defects such as damage from lightning, heavy equipment, etc.

In some cases an additional value point may be added if a tree exhibits an unusually severe lean. As an example, a tree affected by a pathogen causing extensive rot of the main bole and which also leaned heavily, would be given a value of 3 for the structural defect and 1 for the lean, with a final value of 4. This value would indicate the chance of imminent failure was of the highest category.

Element number 2 relates to the type or extensiveness of damage and/or injury which would probably occur if the tree failed. The values for this element are similarly rated 1 - 3, with 3 being the highest, i.e., a tree rated 3 under this element could be expected to do extensive damage or cause injury or death upon failure. As an example, a large tree leaning over a cabin or a number of campsites would be rated as a 3. One on the periphery of a campground leaning away from campsites would be rated as a 1. If it failed, its chance of causing extensive damage and/or injury would be low.

The value for both elements is summed for each tree, and it results in a combined value which is equivalent to the priority for removal. The highest priority is a 7, and a 7 indicates a highly defective leaning tree which will cause extensive damage and/or injury upon failure. The lowest priority which could be assessed is a 2.

---

[1]This statement was prepared by Sequoia and Kings Canyon National Parks; the system described is their standard guide for hazard tree rating in developed sites.